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Real-Time Sensing of Optical Alignment

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The Large Deployable Reflector and other future segmented optical systems may require autonomous, real-time alignment of their optical surfaces. We have developed gratings located directly on a mirror surface to provide interferometric sensing of the location and figure of the mirror. The grating diffracts a small portion of the incident beam to a "diffractive focus" where the desired diagnostics can be performed. If the grating (or gratings) adequately samples light across the mirror, the diffracted signal will track the reflected signal as the mirror is mechanically or thermally disturbed.

We have fabricated mirrors with diffraction gratings in two separate ways. FIGURE 1 describes the formation of a holographic grating over the entire surface of a mirror, thereby forming a Zone Plate Mirror (ZPM). The ZPM could be used as shown in FIGURE 2. The depth of the grating and the exposure of the hologram are used to determine the efficiency and focal length of the ZPM. We emphasize that the grating is very shallow, and since the final reflective coating is done after the formation of the ZPM, the mirror is highly reflective and does not have the appearance of a typical diffraction grating. We have fabricated several very high precision spherical mirror zone plates, and tests indicate that with typical grating efficiencies of a few percent, diffraction-limited point spread functions are produced at both the reflective and diffractive foci.

We have also used computer-generated hologram (CGH) patches for alignment and figure sensing of mirrors. As shown in FIGURE 3, the computer-generated pattern is produced with electron beam lithography equipment. The grating patches are formed on the mirror substrate using a flexible mask and contact replication. As in the two-beam holography method described above, the final reflective coating subsequently placed on the mirror leaves a surface that appears to be a conventional mirror. We have successfully tested this approach with a breadboard containing three grating patches on a large curved substrate.

When appropriately illuminated, a grid of patches spread over a mirror segment (FIGURE 4) will yield a grid of point images at a wavefront sensor, with the relative location of the points providing information on the figure and location of the mirror. A particular advantage of using the CGH approach is that the holographic patches can be computed, fabricated, and replicated on a mirror segment in a "mass production" 1-g clean room environment; it is not necessary to simulate the thermal and 0-g environment that may be needed for the more conventional holographic approach.

ZPM Fabrication

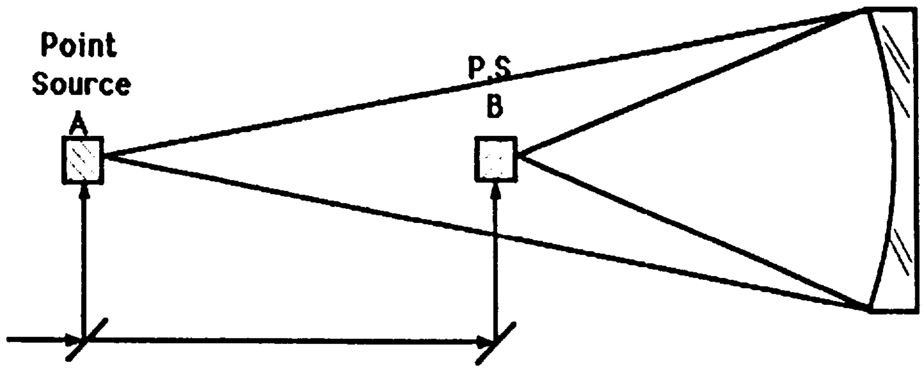

FIGURE 1. The Zone Plate Mirror is produced by illuminating the mirror with coherent point sources at A and B, and recording the interference pattern.

ZPM Application

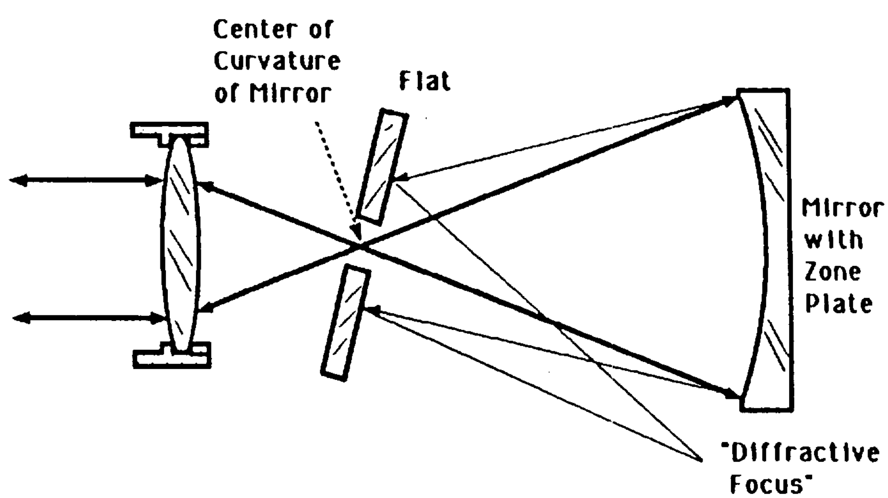

FIGURE 2. The Zone Plate Mirror produces an image at a convenient location for on-orbit alignment.

Grating Patch Fabrication

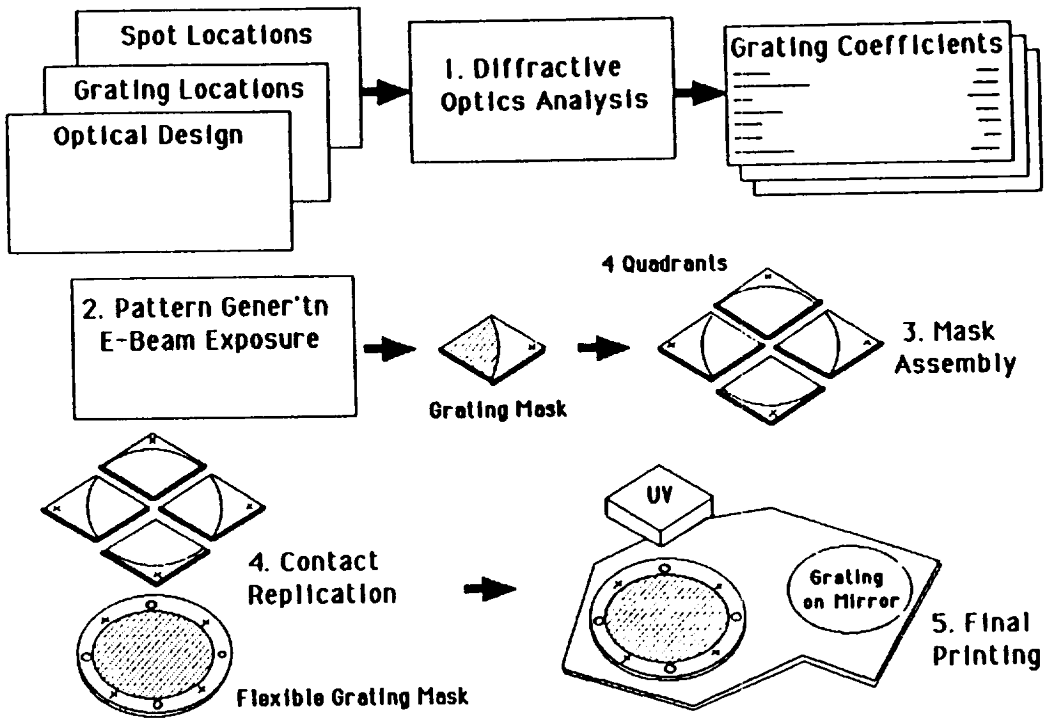

FIGURE 3. Flow chart illustration of the steps required to create computer-generated holographic (CGH) patches.

Mass Production by Contact Printing

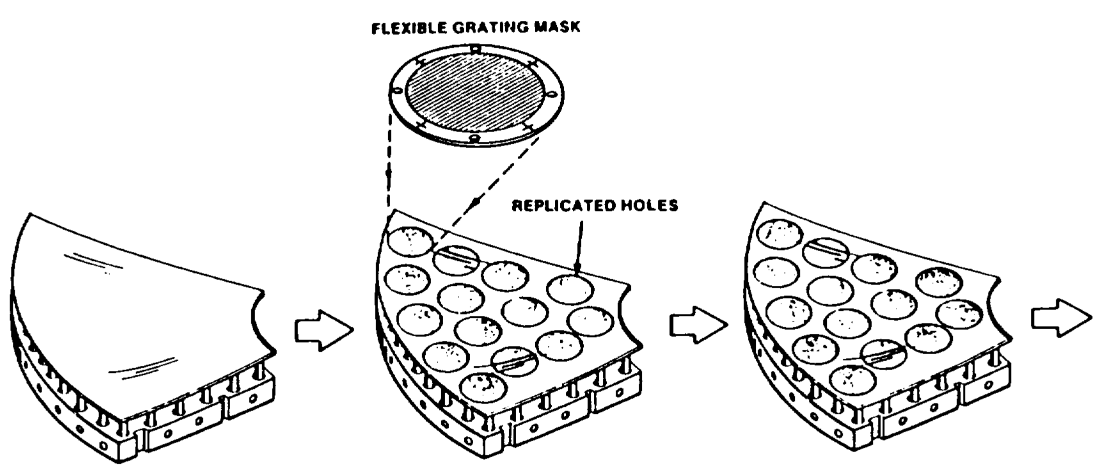

FIGURE 4. A set of reusable flexible grating masks can be used to replicate a grid of patches across the surface of mirror segments.

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